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ABSTRACTS FROM ASTRONOMICAL PUBLICATIONS.

COMPARISON BETWEEN THE DISTRIBUTION OF ENERGY IN THE SPECTRUM OF THE INTEGRATED LIGHT OF THE GLOBULAR CLUSTER MESSIER 3 AND OF NEIGHBORING STARS.[1]

This investigation is based on a spectrogram of the cluster secured with a prismatic camera of ultra-violet glass. The spectrum of the cluster, together with those of the simple stars with which it is compared, appear upon the same plate. In making the exposure the plate was allowed to drift, so that the stellar spectra are sensibly broadened, and are comparable with that of the cluster.

The comparisons were made by means of a Hartmann microphotometer, and the values of the density steps were determined from an objective grating plate by the well-known method of HERTZSPRUNG.

The observations, being photographic, are practically limited to that part of the spectrum to the violet of 5000 A; they are supplemented, however, by visual estimates of the difference in magnitude between the cluster and one of the comparison stars, the author assuming that the visual measures correspond to an effective wave-length of 5600 A. The differences in magnitude, in the sense cluster-star, for three wave-lengths are exhibited in the following table, based on a comparison of the cluster with four different stars:

	Star	+ 27°2288	+ 28°2259	+ 28°2254	+ 28°2248
	Spectrum . . .	F_3	A_4	F_1	K_1
Wave-Length	Viz. Mag. Potsdam . . .	8.24	8.25	7.28	6.37
3761 A	. . . .	+ 0.14 mag.	— 0.03 mag.	+ 1.01 mag.	— 0.22 mag.
4555	. . . .	+ 0.09	— 0.09	+ 0.96	+ 1.14
5600	. . . .	— 0.63	— 0.64	+ 0.33	+ 1.13

According to FATH, the spectrum of the star-cluster under consideration lies between A and G.

A remarkable feature of the cluster *Messier* 3 is exhibited in the table here reproduced, and also in the intensity curves which illustrate the paper. To the violet of 4555 A the light curve of the cluster closely approximates that of first three (early type) stars, while in the yellow the cluster is much stronger.

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[1] By E. HERTZSPRUNG, *Astrophysical Journal*, **41**, 10, 1915.

The color index of the cluster seems to be somewhat greater than that of a star of the same spectral class. This appears to be a characteristic of the spectra of such clusters as have been observed.

What strikes the reviewer as a weak point in such comparisons is the insufficiency of our knowledge of the so-called spectral class of the clusters, and indeed Professor HERTZSPRUNG remarks that the differences in relative intensity to which attention has been called, in the case of *Messier* 3, may be due to the possibly composite character of the integrated spectrum of the cluster. In addition he truly remarks that "in questions bearing on selective extinction of light in space the spectral class on one side and the distribution of energy on the other should at least be derived from an examination of the same region of the spectrum."

As the result of some experience in the observation of faint spectra the reviewer not only agrees with the view here expressed, but is inclined to go further. Clusters are, in general, so faint that, except in a few instances, our knowledge of the so-called spectral class of one of these objects rests upon observations of its integrated light made with spectroscopes of very weak dispersion. While such instruments as these may well serve to place the class of a simple spectrum, the spectrum that is of a single star, the determination of the prevailing class of a group of many stars is an accomplishment of an entirely different order and one beyond their power. On account of the great breadth of the hydrogen and other lines in the spectra of the so-called early stars, together with the relatively great strength of these spectra in the violet, the tendency would always be to place the spectrum of a mixed cluster too *early,* while the effect of the older stars in strengthening the yellow would be fully felt. It is very doubtful whether, with weak instruments, the matter would be improved by extending the observations for class over the visible part of the spectrum, since here the lines which are characteristic of the relatively old stars, say of Classes G or K, are comparatively narrow, and with low dispersion, to say nothing of the disturbing influence of superimposed spectra, would not record. The reviewer is therefore inclined to doubt the value of any assignment of class to the spectrum of a cluster, where such assignment is made on the basis of the integrated light of the object. Our only reliable guide in such matters seems to lie in observations of the character of those of PEASE, already referred to, of the spectra of individual stars, but unfortunately such observations are always difficult, and in many cases impossible, on account of the faintness of the objects.[1] W. H. WRIGHT.

March, 1915.

SPHERICAL ABERRATION IN ASTRONOMICAL OBJECTIVES DUE TO CHANGES OF TEMPERATURE.[2]

The 30-inch objective of the Thaw photographic refractor for the Alleghany Observatory was completed last summer by the JOHN A. BRASHEAR COMPANY, and installed in the tube and dome which had long been awaiting it. In the tests made in the optical shop, where the temperature conditions are under full control, the objective gave almost perfect definition, indicating that the glass in the lenses is of unusual excellence. The Thaw telescope has been in systematic use since last September.

When the objective was first tested in the telescope, by means of stellar images, it was found that the focal lengths of the outer zones were shorter than for the central and intermediate zones. Repeated tests showed that the amount of this aberration varied from night to night and even in the course of a single night. Professor SCHLESINGER's analysis of the observed data indicated that the aberration is the effect of temperature and that it is greater when the temperature is falling rapidly, as for example, during the early hours of the night. He has devised interesting means for removing this temperature effect. The objective end of the telescope is enclosed during the day-time by a metallic cover which acts as a kind of temperature case. This device maintains thruout the day substantially the same temperatures in front of and behind the objective. This covering is removed about an hour before observing begins in the evening, and at the same time a small electric fan, mounted near the upper end of the telescope tube, is caused to blow a continuous current of air into the tube thru a large vent just below the rear surface of the objective. Two other similarly placed vents permit the air to escape from the tube. The effect is to cool the rear surface of the objective about as rapidly as the front surface is cooled by natural circulation of the air.

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[1] Mr. PEASE has photographed the spectra of nineteen separate stars in the cluster in *Hercules, Messier* 13. He finds all classes from A to G, Class F5 being the most numerous.—*Annual Report of the Director of the Mount Wilson Solar Observatory,* 1913, p. 219.

[2] Abstract of Professor SCHLESINGER's article in *Proceedings of the National Academy of Sciences,* Vol. I, No. 1.

The front lens (flint) is separated from the rear lens (crown) by nearly half an inch. The metal cell which holds the two lenses in place is pierced by half a dozen holes one-half inch in diameter, at the edge of the air space which separates the two lenses. These permit the air to circulate between the two lenses.

The ventilating fan is placed in the circuit with the electric lights which illuminate the setting circles of the telescope. The observer naturally turns these lights on at the close of each photographic observation, for the purpose of finding the next object, and turns them off after the second object has been found. The fan is therefore in operation between successive exposures, thruout the night.

When the night's work is over the objective is covered with the metal temperature covering, and the three large and the three small openings in the tube are closed.

These devices have removed the aberrations due to differences of temperature in the lenses. When the temperature of the lenses and surrounding atmosphere is uniform, the figure of the objective as tested upon the stars has been found to be excellent.

W. W. Campbell.

A Faint Star with Large Proper Motion.

In *Astronomische Nachrichten,* 4775, Professor Max Wolf gives an account of a star of the thirteenth magnitude (R. A. 1875.0 $= 2^h\,6^m\,54.^s0$; Decl. $+ 15^\circ\,24'.4$), which has an annual proper motion of about $+ 1.''1$ in right ascension, the motion in declination being very small. This remarkably large motion for so faint a star makes the discovery one of unusual interest, but in connection with it, Professor WOLF has made an observation, which, so far as my knowledge goes, is unique. A star of the fifteenth magnitude was found on the earlier plates (about 1894), south and east of the thirteenth magnitude star and close to it. The motion of the latter, in the following years, carried it directly across the line of sight to the former, causing an occultation that was almost central. In 1914 the fainter star was just discernible, emerging on the southwest limb of the disc of the proper motion star. R. G. AITKEN.

March, 1915.

A NEW LINE IN THE SPECTRUM OF THE SOLAR CORONA.

The Spanish eclipse expedition to Crimea to observe the total eclipse of August 21, 1914, consisted of Messrs. ASCARZA, CARRASCO, and TINOCO.[1] The station selected was Theodosia, 45° 3′ 2″ north latitude. A Grubb coelostat, Rowland plane grating of 15,000 lines to an inch and an objective of 8^{cm} aperture and 120^{cm} focal length formed the spectrograph of Mr. CARRASCO. ILFORD panchromatic and Wratten M′ plates were used. Attention is directed to a new coronal radiation discovered by Mr. CARRASCO on a plate, of 12 seconds exposure, taken 13 seconds after the second contact. The computed wave-length of the new line, measured with reference to $H\alpha$, D_3, and $H\beta$ is 6378.87 ± 0.036 A.

In the *Comptes Rendus* for December 7, 1914, Mr. DESLANDRES presents a communication by MM. J. BOSLER and H. G. BLOCK with reference to the results of the Meudon eclipse expedition to Strömsund, Sweden. The inspection of the Strömsund plates shows that the continuous spectrum of the corona was perfectly regular; that the well-known green radiation at λ 5303.7 was absent and that a brilliant and intense new radiation appeared in the red part of the spectrum. The wave-length is given as 6374.5 ± 0.2 A. and agrees well with that determined by Spanish astronomers. This radiation is a new addition to the spectrum of the corona, and like some other coronal radiations, seems to be connected with the state of solar activity at the time of eclipses.

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[1] *Comptes Rendus*, Vol. 159, N. 22.

M. SELGA, S. J.

MOUNT HAMILTON, January 25, 1915.

SPECTRUM DIFFERENCES AND ABSOLUTE MAGNITUDES.

A recent investigation by Mr. W. S. ADAMS, of Mount Wilson, has shown that the intensity of the violet region relative to the red region is less in spectra of stars of small proper motion than in stars of large proper motion. This may be due to absorption in space or to difference in luminosity or absolute magnitude. In further study[1] he has derived evidence that spectral differences are due to stellar atmospheres and are possible criteria of absolute magnitude. Two groups of stars are investigated, one of small proper motions and one of large proper motions, each containing stars of the several classes from F to K. Two facts are immediately evident: The violet region is relatively weaker in the small proper-motion stars, and the difference increases with spectral class. The hydrogen lines are unusually strong in the small proper-motion stars and certain metallic lines systematically differ in intensity in the two groups of stars. The relative intensities of the violet and red regions were determined by comparisons under the Hartmann spectrocomparator with a series of different exposures on *α Tauri*, and all estimates for all the plates were reduced to a uniform series of densities. Since the difference between the violet and red increases with the type, and the ratio of the proper motions, assumed to indicate the ratio of distances, is nearly the same for each type, therefore more or less of the violet absorption must be due to stellar atmospheres. If the unusual strength of the hydrogen lines were due to hydrogen in space, the radial velocities from the hydrogen lines would differ from those given by metallic lines. But practically no difference is found, so that the hydrogen absorption must be in the stellar atmospheres.

A relation between changes in the line intensities and the absolute magnitudes is next sought for. Pairs of lines were selected, usually a hydrogen and a metallic line, and their relative intensities estimated on an arbitrary scale after the manner of the Argelander step-method for variable stars. After classifying the stars by the changes found, normal curves for each pair of lines were formed for each spectral class. The residuals from these curves were averaged for two groups of stars, those of low absolute magnitude and those of high absolute magnitude, these magnitudes being determined from the known parallaxes or from proper motion by means of KAPTEYN'S formula. Linear relations were then derived between these mean residuals and the absolute magnitude:

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[1] *Astrophysical Journal*, ~~5~~40, 385, 1914.

For Classes F8–G6, $M = +5.6 - 1.6D$.
For Classes G6–K9, $M = +6.8 - 1.8D$.

The relation is thus practically the same for all of the spectral classes. The magnitudes derived with these formulæ agree well with those derived from parallax or proper motion, the mean difference being only one and a half magnitudes. Spectrum differences therefore may possibly lead to determinations of absolute magnitudes. G. F. PADDOCK.

AN APPARENT PECULIARITY IN THE DISTRIBUTION OF PERIODS AMONG SPECTROSCOPIC BINARIES.

At the Observatory of Lund a catalog of statistics of spectroscopic binaries has been compiled.[1] It includes about 440 binaries. The periods of 88 are known and also of 16 binaries of the δ *Cephei* class. These 88 binaries have been divided into groups of Class B, Class A, classes F to K, and Class M. The distribution in each group with respect to the logarithm of the period shows a division of the binaries into two groups of different order of period; in other words, the frequency curves of each spectral group and of all combined show two maxima. Even tho the number of binaries is small and probably insufficient, the possibility of accounting for this apparent evidence of two orders of period is discussed.

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[1] *Meddelande fran Lunds Astronomiska Observatorium,* No. 63, 1914.

From the relation between the period, the semi-major axis, and the total mass, $P = \frac{a^{3/2}}{M^{1/2}}$, it is seen that the two orders of period might be accounted for by two orders of mass, or two orders of semi-major axis, or two orders of age of the systems, if the semi-major axis increases with time as suggested by DARWIN. It is not likely that two orders of age would explain the two orders of period in all the spectral classes separately. It is quite possible that there exist two orders of mass; altho the Cepheids which are thot to have small mass fall in the short period group, and the systems of longest periods have large amplitude of radial velocity, which is inconsistent with the relation $M :: K^3P$, which indicates that the amplitude K must be small in case of small mass. It is possible that two orders of mass would cause an analogous division of luminosities or of densities. A table of the frequencies of absolute magnitudes of these binaries based upon KAPTEYN'S list of parallaxes shows, however, that there is no division into two orders of magnitude. A table of frequencies of periods and the densities as published by SHAPLEY[1] for eclipsing variables, shows a slight indication of double grouping, that is, the long-period systems have small density. If this grouping is actual and if low density corresponds to small mass, this result favors the hypothesis of two orders of mass. But in eclipsing systems, especially those with large orbits, the components must have large size or volume and tho the density be small, the mass may still be great. Hence the data of eclipsing systems does not necessarily support the hypothesis of two orders of mass. In fact, there seems to be no real support for that hypothesis.

The remaining hypothesis of two orders of semi-major axis has the following point in its favor: Since the eccentricity increases with the period and the semi-major axis, there may exist two orders of eccentricity. A table of frequency of periods and eccentricities gives an indication of two orders or at least a discontinuity in the order of eccentricity. This evidence gives strong support to the hypothesis of two orders of semi-major axis. Explanation of it is not attempted, but it suggests two principles of generation, such as partition of mass for the short periods and capture of bodies in the case of long periods.

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[1] *Astrophysical Journal* **38**, 158, 1913.

Finally, it must not be forgotten that with an increasing number of computed binary orbits the grouping and division in the frequency curves may disappear.

G. F. PADDOCK.

THE RELATION BETWEEN PERIODS AND ECCENTRICITIES OF SPECTROSCOPIC BINARIES.

After a five-years' interval since Dr. SCHLESINGER's discussion of spectroscopic binaries in 1910,[1] Mr. F. C. JORDAN, of the Alleghany Observatory, has collected all spectroscopic binary orbits for a second investigation of their periods and eccentricities.[2] At the former time there were 50 orbits, excluding Cepheid variables, while now there are 82 orbits, excluding those of binaries of the δ *Cephei* class. This represents an increase of 60 per cent in the number of published orbits and gives a good idea of the increasing interest and study of spectroscopic binaries. Mr. JORDAN has divided the 82 systems into four spectral groups, containing respectively Classes Oe5 to B8, Ao to A5, Fo to F8, G to M. Each group is arranged in order of period, the range of which for the successive groups is 0.1 to 180 days; one to 2175 days, one to 28 days, 19 to 2118 days. The tabulation at once shows that, altho the eccentricity is greater the greater the period, the magnitude of the eccentricity presents discontinuities respectively at periods of 13, 9, 15, 105 days. Before and after these discontinuities, within any group, the eccentricity does not increase with the period. Moreover, the means of the eccentricities within the four spectral groups show no increase or progression. The mean of all the eccentricities is 0.22, altho they range from zero to 0.88. Mr. JORDAN's conclusion is that increase of eccentricity is not concomitant with progression in spectral class. This tabulation and discussion show that there are apparently two orders of eccentricity within each spectral group of spectroscopic binaries. Mr. SVEN WICKSEL's intimation of two orders

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[1] *Publ. All. Obs.* **1**, 135.
[2] *Publ. All. Obs.* **3**, 158.

of eccentricity, mentioned in the preceding note, on the apparent two orders of periods among spectroscopic binaries is thus well supported.
G. F. PADDOCK.

ON PROFESSOR TURNER'S THEORY OF A SUN-SPOT SWARM OF METEORS ASSOCIATED WITH LEONIDS: R. A. SAMPSON.

About a year ago[1] I gave an abstract of Professor H. H. TURNER'S novel theory to account for the sun-spots and the changes in their periodicity and noted that no critical comment on the theory had been published. Such a critical review is now given by Professor SAMPSON under the title quoted above.[2]

The first point advanced against the theory is that it would require us to attribute an improbable mass to the Leonids. On the assumption that the Leonids have a mass three times that of the Earth, it is shown that an "encounter" with a meteor swarm like the SSS (sun-spot swarm) at the distance of *Saturn* from the Sun would produce changes in the revolution period of the latter of the order of 1/10,000, whereas TURNER'S theory requires changes of the order of 1/10. To bring these fractions to equality would require a vast increase in the mass of the Leonids.

The second point of attack is directed upon "the encounter which the theory requires of *Saturn* with the Leonids at intervals of 9 revolutions of the former and 8 of the latter, that is to say, about 266 years." Professor SAMPSON bases his argument on a comparison of the best known orbit of the Leonid swarm and that of *Saturn* and concludes that there is no valid evidence of such encounters.

A most interesting feature of Professor SAMPSON'S investigation relates to the date commonly assigned in text-books for the introduction of the Leonids themselves into our system by the action of the planet *Uranus*. This date is given as A. D. 126, upon the authority of LEVERRIER. It appears that LEVERRIER'S work is not conclusive and that it is far more probable that the Leonids were thrown into their present orbit by the action of *Uranus* about A. D. 885. The fact that the first

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[1] See these Publications **26**, 110, 1914.
[2] Mon. Not. R. A. S. **75**, 82, 1914.

Leonid shower of which we have well attested records occurred in A. D. 902, lends strong support to this conclusion. Professor SAMPSON draws particular attention to this point, as an illustration of the danger of accepting a theory simply "upon the credit of a name."

It should be added that in the following number of the *Monthly Notices,*[1] Professor TURNER replies to Professor SAMPSON'S criticism of his theory. His argument, briefly, is that the latter "has omitted to take any account of the difference between a small compact planet and a large extended meteor-swarm." He thinks that such an extended swarm could produce the perturbations in the SSS called for by his theory without assigning to it any improbable mass.

As for Professor SAMPSON'S second point, he argues that the Leonids we know may be only a small part of the whole swarm; that the main swarm may have a slightly different orbit which would meet the conditions imposed by his theory, and, further, that the orbit of the Leonids, in general, is not nearly so well known as Professor SAMPSON assumes it to be. He adds, "I am well aware that this is only sketching possibilities instead of testing them, and that such sketches as I have given carry with them responsibilities to the discharge of which nothing has yet been done." His concluding paragraph gives the promise of further work upon the problem.

R. G. AITKEN.

March 6, 1915.

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[1] **75**, 138, 1915.